RAINBOW TROUT BROODSTOCKS FOR COARSEFISH LAKES

Habitat Conservation Fund
Final Report (1993-94)

by

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ABSTRACT

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Growth and relative survival of progeny developed from rainbow trout (Oncorhynchus mykiss) brood fish inhabiting coarse fish environments and progeny from rainbow trout brood fish from a monoculture lake were compared in coarsefish lakes. The study was conducted using Blackwater River, Tsuniah, Bootjack and Tzenzaicut lakes strains (coarsefish trout strains) and the Pennask Lake strain (monoculture strain) in lakes with one or more coarse fish species. Coarse fish species included coarsescale sucker (Catostomus macrocheilus), longnose sucker (Catostomus catostomus), redside shiner (Richardsonius balteatus), peamouth chub (Mylocheilus caurinus), and northern squawfish (Ptychocheilus oregonensis). For three consecutive years, a combination of two coarsefish rainbow trout strains plus the Pennask strain were stocked as one-year-old fish into eight study lakes in May 1990 to 1992, and first sampled with gillnets after a five month period. In 1993, the final year of the project, three of the study lakes were stocked with Blackwater, Tzenzaicut, and Pennask strain rainbow trout yearlings. Overall, relative survival of Tzenzaicut and Bootjack fish was better than Pennask. Blackwater recovery rates were inconsistent between broodyears and lakes and Tsuniah fish had consistently lower recovery rates than the Pennask strain. Size at age 1+ of Tzenzaicut, Blackwater, and Tsuniah fish was greater than Pennask and no different for Bootjack. At age 2+, all four coarsefish rainbow trout strains weighed significantly more than Pennask. No differences were found in stomach fullness or stomach content weights for fish caught during regular sampling periods. Incidence of piscivory for Blackwater strain rainbow trout was consistently higher than for other strains. Blackwater fish consumed larger size prey items such as molluscs, more frequently than any other trout strain. The percentages of males maturing early to spawn at age 2, were significantly lower than Pennask for three coarsefish rainbow trout strains. Overall precocious male rates for Tzenzaicut, Blackwater, and Bootjack fish were 8.1, 12.3, and 17.6 respectively, while Tsuniah and Pennask fish had 35.1 and 31.4%, respectively. Alternate stocking rates for coarsefish rainbow trout strains, equivalent to established release rates for Pennask stocked coarsefish lakes, are derived from relative survival rates observed in study lakes. The Pennask equivalent stocking rates or PE stocking factors for Blackwater, Tzenzaicut, Bootjack, and Tsuniah strain fish were determined to be 0.99, 0.50, 0.66, and 1.47, respectively. This stocking factor suggests that when Tzenzaicut rainbow trout are used as an alternative strain to Pennask in coarsefish lakes, only 50% of the stocking rate for Pennask is required to maintain an equivalent fishery in the lake, if only relative survival rate is considered.

INTRODUCTION

Lakes supporting coarse fish populations constitute 53%, by area, of all named lakes in southern B.C. (data on file). At the present time, progeny from mainly monoculture lakes rainbow trout brood fish are stocked into these waters. Data collected to date suggest that progeny of wild rainbow trout originating from established populations in coarsefish environments can grow and survive better than a monoculture rainbow trout strain, when stocked into coarsefish lakes (Blann and Tsumura 1988, 1989, Godin and Tsumura 1992, 1993).

It is well documented that differences in inter-strain behaviour may influence growth, survival and catchability in rainbow trout (Ayles and Baker 1983, Babey and Berry 1989, Brauhn and Kincaid 1982, Fay and Pardue 1986, Hudy and Berry 1983, Hume and Tsumura 1992). These differences can be a valuable management tool in the enhancement of lake systems, once it has been established that certain conditions favour specific strains (Behnke 1992, Babey and Berry 1989). Selective differences in food preference, spatial distribution, and feeding behaviour of rainbow trout strains should be considered for the most effective utilization of available food resources in a system. After appropriate trout strains are identified, strain specific management should be regarded as an option for enhancement of fisheries, in coarsefish lakes. This will require adjustments to the stocking program if survival of coarsefish rainbow trout strains, relative to survival of trout strains previously stocked into coarse fish lakes, differ significantly.

This project continues to investigate growth, relative survival, maturation rates, and incidence of piscivory in rainbow trout strains native to a monoculture and coarsefish environments stocked into coarsefish lakes from 1990 to 1993. In this report, age 2+ progeny of rainbow trout brood fish from four different coarsefish environments (Blackwater River, Tsuniah Lake, Bootjack Lake, and Tzenzaicut Lake) are compared to rainbow trout from monoculture Pennask Lake. For age 1+, only Blackwater, Tzenzaicut and Pennask strain rainbow trout (1992 broodyear progeny) are compared. Figures and appendices provide a summary of fish data collected from 1989 to 1993.

STUDY LAKES

This study utilized eight small lakes, 7 - 58 ha in size, distributed throughout the Kamloops (Region 3), Okanagan (Region 8) and Cariboo (Region 5) districts (Fig. 1). These lakes are situated in two limnological (Southern Interior Plateau, Southern Interior Highland) regions of B.C., as described by Northcote and Larkin (1956). Mathew, Garcia, Skmana, Forest, Starlike, Buchanan and Gladstone lakes, are situated in the Southern Interior Plateau region. Lakes in this area are described as generally productive (TDS > 200 ppm) with extensive plankton and benthic fauna and variable fish quantities. Pear Lake is located in the Southern Interior Highland region where most lakes have a TDS lower than 100 ppm, and have low production values for plankton, benthic fauna, and fish.

The physical characteristics and the diverse coarsefish composition of these study lakes are summarized in Appendix 1 (from Facchin and King 1980a, 1980b, 1980c, 1983). Natural and man made barriers prevent migration in all study lakes at low flows, but opportunities exist for passage from some lakes periodically during the year.

Mathew and Garcia lakes are located on private property and are closed to fishing. The outlet creek of Mathew Lake flows into Garcia Lake. Fish are able to migrate down Godey Creek, a small outlet creek of Garcia Lake, during high flows, into a 0.5 ha pothole. This pothole was also gillnetted.

Buchanan Lake has road access only through private property and is subject to very low angler effort. This lake contained rainbow trout populations in the past, but was devoid of trout previous to the 1990 stocking.

Forest, Skmana, Gladstone, Pear, and Starlike lakes are easily accessible and receive moderate angling pressure.

METHODS

For three consecutive years from 1989 to 1991, rainbow trout progeny from the Blackwater River (Blak), Tzenzaicut (Tzen), Bootjack (Boot), Tsuniah (Tsun), and Pennask (Penn) lake systems were raised in the quarantine section of the Abbotsford Research Hatchery. In 1992, only coarsefish rainbow trout strains from the Blackwater River and Tzenzaicut Lake were raised as these two coarsefish rainbow trout strains performed the best relative to the Pennask control strain. Experimental broodfish strains originated from systems that have thriving wild rainbow trout and dense coarse fish populations. Pennask Lake rainbow trout originate from a monoculture, wild population that has never been supplemented by stocking. An annual egg collection of approximately one million eggs is conducted by the Fish Culture Section from the spawning run in Pennask Creek. Eggs were collected from all strains during a one month period in May and June. Progeny were reared to age 1 under the same hatchery conditions, targeting for similar release weights for all strains (Table 1). All fish were marked with a fin and/or maxillary clip (Appendix 2), and then released, within a 10 day period, into eight study lakes from 1990 to 1992, and into four study lakes in 1993 (Table 2). Each study lake received the Pennask control strain plus two coarsefish rainbow trout strains. In the fall of 1992, Buchanan Lake was also stocked with Blackwater, Tzenzaicut, and Pennask strain rainbow trout fry in order to compare survival rates to yearling releases in coarsefish lake environments.

Table 1. Mean weight (g) of yearlings and fry (f) at the time of release.

BROOD YEAR	STRAIN				
	BLAK	TZEN	BOOT	TSUN	PENN
1989	23.3	23.0	20.3	19.3	20.7
1990	24.4	23.2	22.4	22.6	24.6
1991	24.9	25.6	18.9	22.5	16.7
1992	19.9	23.2	-	-	19.6
1992 (f)	2.4	1.6	-	-	3.1

Summer and Fall Sampling in Study Lakes

Study lakes were sampled with gillnets over a 4 week period between September and October each year. Two types of floating monofilament nylon gillnet gangs with panels of differing mesh size were used. One type was comprised of 38.1, 50.8, 63.5 and 76.2 mm size meshes in 15.2 m long panels. Panels were randomly distributed in the gangs. The gangs ranged in length from 107 to 122 m (7 or 8 panels) and fished a depth of 1.8 m with a few exceptions. In Mathew and Garcia lakes, two gangs (91.4 m of net) fished a depth of 4.9 m. Buchanan and Starlike lakes had 61 and 30.5 m of the deeper nets, respectively.

The second type was comprised of 12 panels, each 3.1 m in length. These gangs had panels with sequential mesh sizes of 31.1, 50.8, 79.4, 41.3, 63.5, and 101.6 mm. Nets were set in similar littoral and limnetic locations, with the same effort as in previous years (Tsumura and Godin 1991). Nets were usually set at 1500 hrs, to fish through dusk and left overnight for 24 or 48 hour periods.

Mathew and Garcia lakes were sampled monthly during the final summer of the project to obtain feeding differences. Gladstone Lake was gillnetted in the fall of 1993, but no fish were caught possibly due to winterkill.

Length, weight, clip, sexual maturity and gut content were recorded for each fish caught.

Stomach Content Comparisons

Gut contents from trout strains recovered from Garcia and Mathew lakes were preserved in 80% isopropyl alcohol and examined macroscopically. Intact organisms were

blotted on a paper towel and weighed using a Mettler™ PC440 electronic balance. Evidence of piscivory and general occurrence of prey items were recorded.

Table 2. Number of yearlings and fry (f) of each strain stocked into study lakes over four years.

LAKE	BROOD YEAR	TOTAL NO. STOCKED	STRAIN				
			BLAK	TZEN	BOOT	TSUN	PENN
GARCIA	1989	4500	1500			1500	1500
	1990	4064	1500			1500	1064
	1991	4500	1500			1500	1500
	1992	2250	750	750			750
STARLIKE	1989	4900	2000			2000	900
	1990	5985	1982			1988	1988
	1991	6000	2000			2000	2000
MATHEW	1989	1500	500	500			500
	1990	1500	500	500			500
	1991	1500	500	500			500
	1992	1200	400	400			400
GLADSTONE	1989	3150	1000	1000			1000
	1990	3000	1000	1000			1000
	1991	3000	1000	1000			1000
SKMANA	1989	3150		1000	1000		1150
	1990	3000		1000	1000		1000
	1991	3000		1000	1000		1000
PEAR	1989	3150		1000	1000		1150
	1990	3000		1000	1000		1000
	1991	3000		1000	1000		1000
BUCHANAN	1989	4500		1500	1500		1500
	1990	4500		1500	1500		1500
	1991	4500		1500	1500		1500
	1992 (f)	3000	1000	1000			1000
	1992	2826	942	942			942
FOREST	1989	4500			1500	1500	1500
	1990	4500			1500	1500	1500
	1991	4500			1500	1500	1500

Statistical Analysis and Assumptions

Strain comparisons were made independently within each lake system. An analysis of variance was performed on logarithmically transformed length and weight data (Sokal and Rohlf 1981) using SYSTAT (Wilkinson 1988) computer software. If significant differences among strains were detected, the means were compared using a Tukey HSD Multiple Comparisons test. Relative survival of rainbow trout strains was indicated by the proportion of each strain in total gillnet catches in each lake. Relative survivals were compared using a chi-square goodness of fit test (Zar 1984).

Assumptions:

1. Gillnet selectivity is negligible since a wide range of mesh sizes was used.

2. Each strain had an equal chance of being caught since both shoal and open water habitats were sampled over a 24 to 48 h period. Gillnet catches of the same broodyear were compared over two or more years to determine if the proportion of different strains caught remained the same.

3. Predation on yearling rainbow trout by squawfish soon after stocking into a lake is negligible. No evidence of released trout was found in guts of squawfish sampled in over-night post-stocking gillnet catches after daytime stockings.

RESULTS AND DISCUSSION

Relative Survival -- comparison of gillnet catches

Relative survivals of the different rainbow trout strains were estimated from gillnet catch. Recovery rates, the total number of fish caught over one or more sampling periods as a percentage of the initial number of fish released, remained relatively constant for the different broodyears (Appendices 3 - 6). Total recovery rates were lower than 10% except in Mathew Lake, where gillnet effort was highest at 120.2 m of gillnet per hectare. Mathew Lake also has the lowest mean depth (3 m), the second lowest lake volume (3.17×10^4 m^3) of any of the study lakes, and has a high percentage of shoal area. Recovery rates in this lake were consistently high over three broodyears with the Tzenzaicut strain having the highest percentage recovered at 40.2 to 67.6%, Pennask strain having the lowest percentage recovered at 23.4 to 24.2% and Blackwater strain having 27.4 to 36.6% recovered. Although the sample sizes from other seven lakes were lower, this relative survival trend was consistent for age 1+ fish. In the three lakes (Garcia, Mathew and Buchanan lakes) that were stocked with the 1992 broodyear of Blackwater, Tzenzaicut, and Pennask rainbow trout, the Tzenzaicut strain again had the best relative survival to age 1+. They were recovered in significantly larger numbers than the control strain in all three lakes. The number of Blackwater fish caught was no different from the Pennask strain in Garcia and Mathew lakes, but was better in Buchanan Lake.

Over the course of the study, comparisons of the relative survival of the coarsefish and monoculture rainbow trout strains showed the Tzenzaicut had the best survival of any of the strains. They were caught in greater numbers in all but three of the 18 comparisons with the Pennask strain (Table 3). The Bootjack strain was recovered in larger numbers than the Pennask in half the comparisons but was no different in the other. Relative gillnet catch of Blackwater fish was not consistent between broodyears and lakes when compared to Pennask. The Tsuniah strain had better survival than the control in only one comparison, the 1991 broodyear in Starlike Lake. Tsuniah rainbow trout were eliminated in 1992 as an alternative strain for managing coarsefish lakes because of their consistently lower survival rates than the Pennask strain.

Table 3. Relative survival of the different strains as measured by the total number of fish from each broodyear recovered in four years of sampling. "P" indicates that Pennask fish were caught in significantly greater numbers than the coarsefish strain. "X" indicates that the coarsefish strain was caught in significantly larger numbers than Pennask. "N" indicates no significant difference.

STRAIN	BLACKWATER				TZENZAICUT				BOOTJACK			TSUNIAH		
Broodyear	89	90	91	92	89	90	91	92	89	90	91	89	90	91
LAKE:														
MATHEW	X	X	N	N	X	X	X	X						
GLADSTONE	X	P	P	--	N	X	X	--						
GARCIA	N	P	P	N				X				P	P	P
STARLIKE	P	P	X									P	P	X
SKMANA					N	X	X		X	N	N			
BUCHANAN				X	X	X	X	X	X	X	X			
PEAR					X	X	N		X	N	N			
FOREST									X	N	N	N	P	N

Size Comparison of strains at Age 1+

Size-at-age 1+ of the Pennask monoculture strain rainbow trout was never significantly better than any of the coarsefish rainbow trout strains, after five months in the lakes for four broodyears (Table 4). Data for the comparisons in Table 4 can be found in Appendices 3-5 in Godin and Tsumura 1993, and Appendix 7 in this report. Blackwater strain rainbow trout were significantly heavier than the Pennask fish in all comparisons made at this age. Tzenzaicut fish not only had a relative survival rate twice that of

Pennask, but they were usually significantly heavier than the Pennask, except in three lakes for the 1989 broodyear and in two lakes in the 1990 broodyear, where there was no difference (Table 4). Bootjack outweighed Pennask in three out of eight comparisons and showed no significant weight difference in the other comparisons. Tsuniah fish had extremely poor survival compared to the Pennask strain, but the average weight was significantly greater than for the Pennask in five out of eight comparisons.

Table 4. Length (L) and weight (W) of age 1+ coarsefish trout strains compared to Pennask for four broodyears. "P" indicates that Pennask strain was significantly greater in length and/or weight than the coarsefish strain. "X" indicates that the coarsefish strain was significantly greater in length and/or weight than the Pennask strain. "N" indicates no significant difference between strains.

STRAIN	BLACKWATER								TZENZAICUT								BOOTJACK						TSUNIAH					
Broodyear:	1989		1990		1991		1992		1989		1990		1991		1992		1989		1990		1991		1989		1990		1991	
	L	W	L	W	L	W	L	W	L	W	L	W	L	W	L	W	L	W	L	W	L	W	L	W	L	W	L	W
LAKE:																												
MATHEW	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X												
GLADSTONE	X	X	X	X	X	X			N	N	X	X	X	X														
GARCIA	X	X	X	X	X	X	X	X							X	X							N	X	N	X	X	X
STARLIKE	X	X	N	X	N	X																	N	X	N	X	N	N
SKMANA									X	N	N	N	X	X			N	N	N	N	N	N						
BUCHANAN							N	N	N	N	N	N	X	X	N	N	N	N	N	N	X	X						
PEAR									X	X	X	X	X	X			N	N	X	X	N	X						
FOREST																	N	N	N	N	N	N	N	N	N	N	N	N

Size comparison of strains at Age 2+

After seventeen months in the lake, size-at-age 2+ data show a similar trend among three broodyears. Length and weight of age 2+ Pennask was either significantly lower or no different from that of coarsefish rainbow trout strains, in eight experimental lakes (Appendix 8). The one exception to this trend was with the Tsuniah fish in Garcia Lake sampled in October. The Pennask fish from the 1991 broodyear were significantly greater in length than the Tsuniah strain but not heavier. Figures 2a-c show typical growth to age 2+ of rainbow trout in Garcia and Mathew lakes and to age 4+ (Appendix 9) in Buchanan Lake. Weight-at-age 2+ of Blackwater strain fish was between 15.9 g and 325.3 g heavier, often more than double that of Pennask.

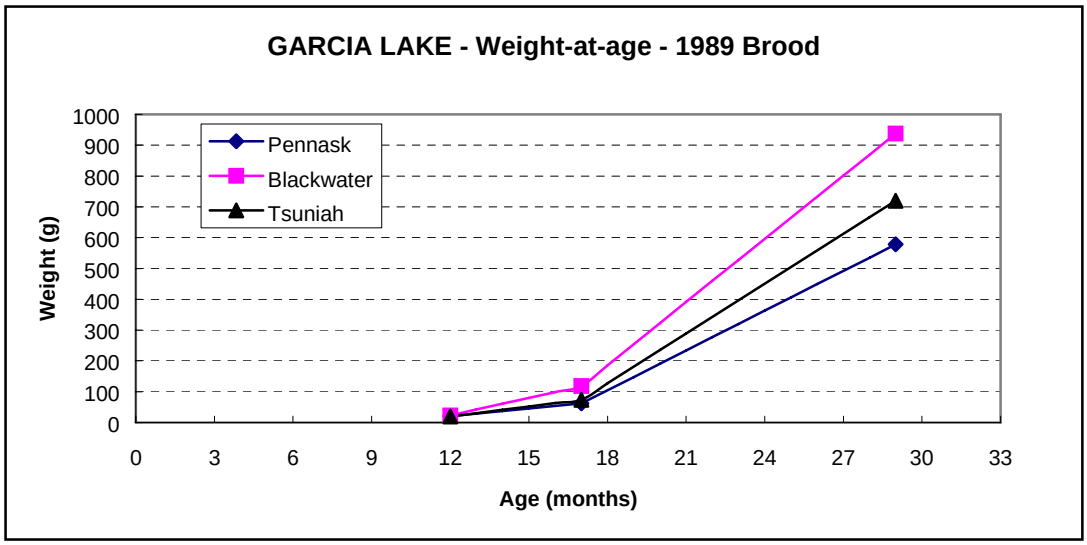

Figure 2a. Graph of weight versus age of the 1989 broodyear Blackwater, Tsuniah, and Pennask control strain rainbow trout in Garcia Lake.

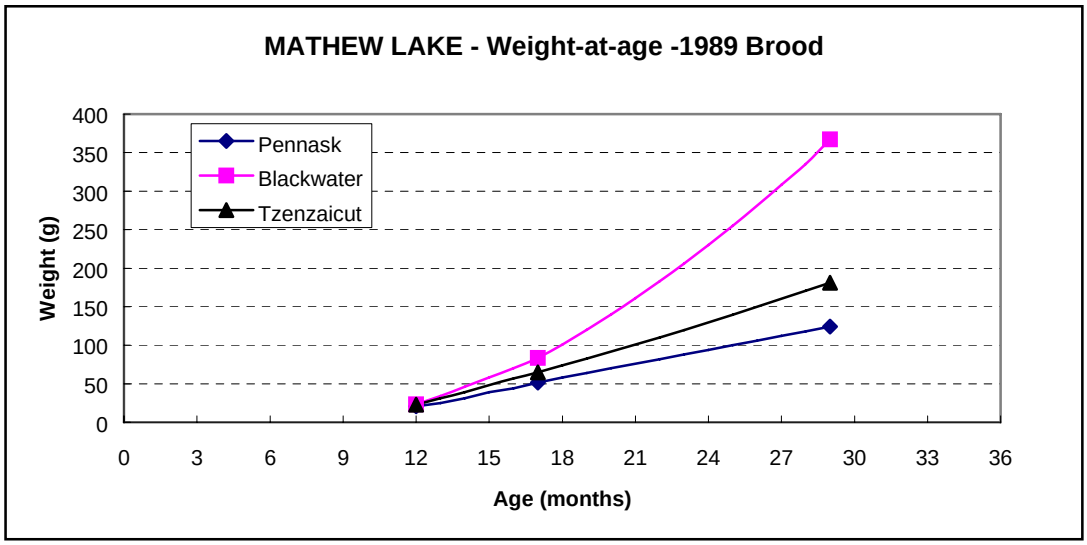

Figure 2b. Graph of weight versus age of the 1989 broodyear Blackwater, Tzenzaicut, and Pennask control strain rainbow trout in Mathew Lake.

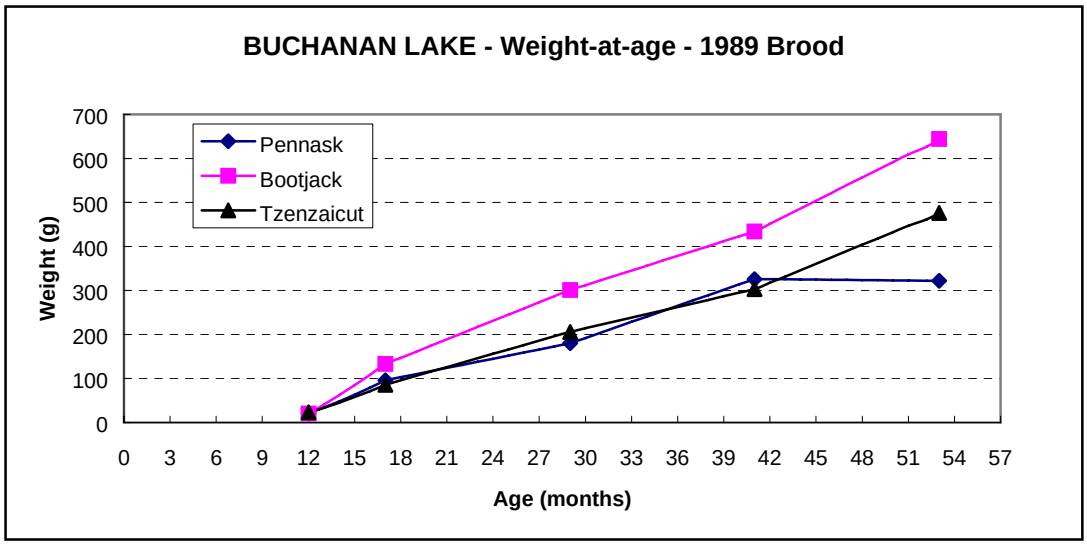

Figure 2c. Graph of weight versus age of the 1989 broodyear Bootjack, Tzenzaicut, and Pennask control strain rainbow trout in Buchanan Lake.

Although there is no particular survival advantage attained by stocking Blackwater over Pennask, except in coarsefish lakes with very dense coarsefish populations such as Buchanan Lake, there is a large advantage to the fishery when considering size-at-age. Tzenzaicut and Tsuniah strain rainbow trout, although not always significantly heavier than Pennask fish, were heavier in all comparisons except one, at age 2+. Tzenzaicut fish were between 7.5 g and 72.5 g heavier (mean 36.0 g) than Pennask, except for the 1991 broodyear in Buchanan Lake (Appendix 10). The Tsuniah fish were between 4.1 g and 430.7 g heavier than the Pennask (mean 70.5 g), except for the 1990 broodyear in Starlike Lake where they were 29.0 g lighter on average (Appendix 7, Godin and Tsumura 1993). Bootjack rainbow trout also had good growth (Fig. 2c) compared to Pennask. Bootjack fish outweighed Pennask in all cases (mean 51.6 g) except for the 1989 broodyear in Skmana Lake, where they were 37.4 g lighter (Appendix 6, Godin and Tsumura 1993).

Comparison of Stomach Contents

The analysis of variance performed on stomach content weights from June gillnetting samples from Mathew and Garcia lakes, showed no significant differences in either fullness of the stomach or blot dry weights of food items, except for age 2+ Tsuniah fish, with stomachs significantly less full than Pennask in Garcia Lake (p=0.03). Appendix 11 shows the stomach fullness and blot dry weights for the fish sampled in June 1993.

The larger sizes attained by the coarsefish rainbow trout strains compared to Pennask may be related to their ability to capture and consume forage fish. Although

Table 5. Number and mean length and weight of trout that ingested coarse fish.

LAKE and trout strain	Age	Month sampled	Sex / Maturity	Mean Length (mm)	Mean Weight (g)
MATHEW					
Blackwater	2	June	FI	378	700.7
Blackwater	2	June	FI	378	649.4
Blackwater	2+	Oct	MM	452	1242
Blackwater	3	June	FI	387	712
Blackwater	3	July	FI	363	609
GARCIA					
Blackwater	1	July	MI	180	66.7
Blackwater	2	July	FI	306	310.1
Blackwater	3	July	FI	394	884
Blackwater	3	June	FI	350	546.6
Blackwater	3	July	MI	403	742
Blackwater	4	June	MI	369	547.3
Tsuniah	2	June	MM	463	835
Tsuniah	2	July	MMR	502	1155
Tsuniah	2	July	FM	450	981
Tsuniah	3	June	FI	360	598.8
Tsuniah	3	June	MI	362	577
Tsuniah	3	July	FI	357	571
Tzenzaicut	1	June	MI	203	95.4
Pennask	1	June	FI	170	52.2
Pennask	4	June	MM	415	790
Pennask	3+	Oct	MM	396	770
Pennask	4	July	MMR	430	845
BUCHANAN					
Bootjack	2+	Sept	FM	291	290
Tzenzaicut	2+	Sept	FM	274	262
Tzenzaicut	4+	Sept	MM	464	1109
Tzenzaicut	4+	Sept	FM	310	381
Pennask	1+(F)	Sept	MI	180	68

Note: Sex : F=female, M=male
Maturity: I=immature, M=mature, R=repeat spawner

Pennask (control) fish were stocked into all eight experimental lakes, few were recovered with evidence of coarse fish in their stomachs, at the time of sampling, throughout the five year study (Blann and Tsumura 1989, Blann et al. 1990, Tsumura and Godin 1991, and Godin and Tsumura 1992 and 1993). In 1993, of the sampled fish, four (1.5%) Pennask fish from Garcia Lake and one Pennask fish from Buchanan Lake showed evidence of coarsefish consumption (Table 5). In Mathew and Garcia lakes, 4.2% of the Blackwater fish sampled contained coarsefish in their stomach. In Garcia Lake, 5.3% of the Tsuniah fish sampled had ingested forage fish. One Tzenzaicut fish was captured with a shiner in its stomach even though only one yearclass was represented in the lake. In Buchanan Lake, 3.1% of the sampled Tzenzaicut fish had consumed coarse fish. Other food items consumed by the strains included molluscs, cladocera, diptera pupae and larvae, notonectidae, chaoborus, corrixidae, dragonfly adults and nymphs, damselfly adults and nymphs, other insects, and organic matter. Molluscs were more prevalent in guts of Blackwater rainbow trout than in any other strain.

Sexual Maturation in Rainbow Trout Strains at Age 1+.

Incidence of age 1+ males maturing to spawn precociously at age 2 varied between lakes, strains and between the same strain in different lakes (Appendix 12). When samples from all lakes and broodyears were combined, the percentage of early maturing males in the Pennask fish was significantly greater than in the Blackwater and Tzenzaicut strains (χ^2, $p<0.005$) but no different than in the Bootjack or Tsuniah fish (χ^2, $0.05<p$). When broodyears are compared individually, the Bootjack strain had a smaller percentage of early maturing males than the Pennask, in two out of three comparisons (Fig. 3).

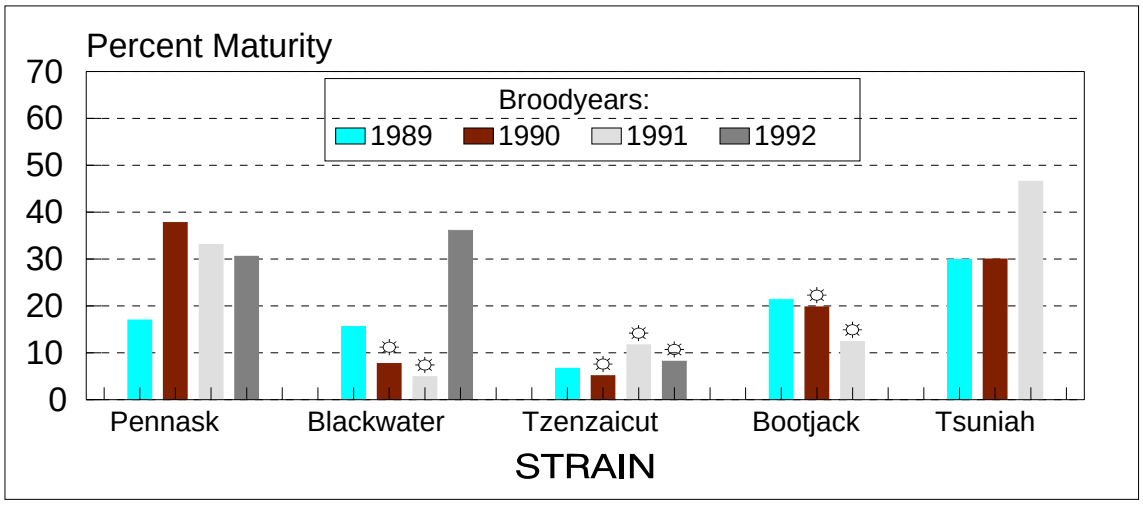

Figure 3. Percentage of males maturing to spawn precociously at age 2 for fish sampled from all lakes combined, for four broodyears. ☼ Indicates the coarsefish strain had significantly lower maturation rates than the Pennask strain.

1992 Broodyear Fry Versus Yearling Release into Buchanan Lake

Preliminary data from rainbow trout collected from Buchanan Lake suggests that in lakes containing coarsefish competitors and predators, stocking yearlings will yield higher returns than stocking fry (Table 6). For rainbow trout sampled over three years since 1993, twice as many Blackwater and seven times as many Tzenzaicut strain trout were caught from the group stocked as yearlings compared to those stocked as fry. Pennask fish that were released as yearlings had lower recovery rates than cohorts released as fry. However, Pennask released as fry were caught in greater numbers than the two coarsefish strains. The effect of the difference in release size on higher relative survival rate is unknown. Pennask fry were released at mean weights 25% greater than Blackwater and 48% greater than Tzenzaicut fry (Table 1).

Table 6. Comparison of fish recovered over three years for the 1992 broodyear rainbow trout stocked as yearlings and as fry.

STRAIN	%Yearlings Recovered	% Fry Recovered
Blackwater	2.9	1.2
Tzenzaicut	8.4	1.2
Pennask	0.8	1.7

Stocking Strategy of Coarsefish Rainbow Trout Strains

Stocking rates for small lakes, including coarsefish lakes, have been developed over the years by regional fisheries managers using monoculture rainbow trout strains such as Pennask. Stocking densities derived for each lake take into account such variables as physical characteristics of a lake, productivity, angler effort, gear types as well as survival rates of stocked fish strains, in order to achieve optimum fishing opportunities for anglers. Therefore, if stocked coarsefish lakes similar to ones used in this study are switched over to coarsefish rainbow trout strains, namely Blackwater and Tzenzaicut strains, which are now being produced by the Fish Culture Section, stocking densities should be adjusted to account for higher survival rates in these fish compared to Pennask.

Stocking densities of the coarsefish rainbow trout strains can be equated to that of Pennask using a “Pennask Equivalent” stocking factor or PE stocking factor in Pennask stocked coarsefish lakes. The PE stocking factor is used to calculate the number of coarsefish rainbow trout strain required to replace previous Pennask strain fish densities to provide the same number of rainbow trout in a fishery (Table 7). Although lake dependent, fewer Blackwater or Tzenzaicut fish are required to be stocked to maintain similar recovery rates in lakes presently stocked with Pennask fish. This number is exacerbated somewhat by including Buchanan Lake in the overall mean. If Buchanan Lake is excluded, PE

stocking factors for these strains are higher at 0.99 and 0.50, respectively. Pennask fish had particularly low survivals in this lake, making the Pennask Equivalent stocking factor for the experimental strains in Buchanan better by a factor of ten. Less than one percent of the Pennask stocked as yearlings into this lake have been recovered. The 1991 broodyear showed the best recovery rate for the Pennask of any of the broodyears at 0.9% or 13 fish. Buchanan Lake has squawfish predators as well as the highest coarsefish densities of any of the study lakes; six peamouth chub are caught in gillnets for every rainbow trout.

Table 7. "Pennask Equivalent" (PE) stocking factors for the four coarsefish rainbow trout strains. The PE stocking factors are the means of three or more broodyears (except Tzenzaicut in Garcia Lake and Blackwater in Buchanan Lake where only one broodyear of the strain was stocked) and are based on total recovery rates of each broodyear in each lake. "( )" indicates mean PE factor excluding Buchanan Lake.

Lake	Blackwater	Tzenzaicut	Bootjack	Tsuniah
Mathew	0.70	0.43		
Garcia	1.33	0.43		1.88
Skmana		0.64	0.70	
Forest			0.69	1.43
Starlike	0.81			1.11
Buchanan	0.09	0.08	0.06	
Gladstone	1.11	0.62		
Pear		0.40	0.60	
Mean PE factor	0.81 (0.99)	0.43 (0.50)	0.51 (0.66)	1.47

The mean PE stocking factor for Tsuniah strain fish is determined to be 1.47. Although growth comparisons favour Tsuniah fish over Pennask fish, it would require that almost 50% more fish be stocked to attain the same survival numbers as Pennask. Therefore, the use of Tsuniah strain rainbow trout would not be an economically desirable alternative for stocking into coarsefish lakes. Survival of Blackwater fish appears to be lake specific. Blackwater fish had PE stocking factors lower than one in three of five lakes and higher than one in the other two. The mean PE stocking factor of 0.99, when Buchanan Lake is excluded, indicates that there is little advantage to stocking Blackwaters in place of Pennask in coarsefish lakes when only survival is considered. However, when growth of Blackwater fish in coarsefish lakes along with other strain characteristics is considered, the stocking of Blackwater fish as an alternate strain to Pennask has many advantages to the fisheries managers as well as to anglers.

Summary

The Tzenzaicut strain of rainbow trout seems to thrive in differing coarsefish environments. They generally survived and grew better than Pennask trout in lakes containing a wide range of coarsefish species such as redside shiners, peamouth chub, coarse scale suckers, and squawfish. Survival and growth to age 1+ and 2+ were always at least similar, but usually significantly better than Pennask. The "Pennask Equivalent" stocking factor of 0.50, suggests that Tzenzaicuts should be stocked at approximately 50% of the stocking rate of Pennask to obtain comparable survival to Pennask fish, in coarsefish lakes. When stocking lakes with extreme conditions such as those found in Buchanan Lake, a coarsefish rainbow trout strain other than Pennask should be considered as the strain of choice as indicated by the PE stocking factors of 0.06 to 0.08. The Tzenzaicut strain also had lower incidence of early maturing males than the Pennask strain. For the four broodyears, Tzenzaicut fish had a mean precocious male rate of 8.1% compared to 31.4% for the Pennask control strain.

The Blackwater strain of rainbow trout also survived and grew well in lakes containing coarse fish. Incidence of fish and molluscs in stomach samples was higher for all broodyears than Pennask. Although the relative gillnet catch of the Blackwater fish was generally no better than that of the Pennask monoculture strain (PE factor = 0.99), their growth was significantly better at age 1+ and 2+. Overall, Blackwater fish had a 12.3% precocious male maturity rate compared to 31.4% for the Pennask fish. Blackwater fish should be considered for stocking coarsefish lakes that have a high ratio of shoal area with no outlets. Blackwaters are a river strain and showed more evidence of migration than the other strains.

The Tsuniah strain rainbow trout were generally less piscivourous than the Tzenzaicut and Blackwater rainbow trout strains. Of the Tsuniah fish recovered in Garcia Lake in fall of 1992, 5.3% had redside shiners in their stomachs. Overall, the Tsuniah rainbow trout strain had lower survival rates than Pennask (PE stocking factor = 1.47). Only in one comparison (1991 broodyear in Starlike Lake) were they caught in greater numbers. Growth, however, was either no different or better than that of Pennask trout. There was no significant difference in the precocious male rates of Tsuniah and Pennask.

The Bootjack strain rainbow trout were piscivorous at a smaller size and consistently at a younger age (age 1+) than the other rainbow trout strains. Bootjack fish as small as 46.6 g had coarse fish in their stomachs. Overall, survival of this coarsefish trout strain to age 1+ and age 2+ was significantly better than that of the monoculture Pennask strain (PE stocking factor = 0.66). Pennask fish were caught in larger numbers in only one instance; the 1990 broodyear in Pear Lake at age 2+. Growth of this strain, however, was no better than that of Pennask at age 1+, but was better at age 2+. In two of the three broodyears compared, Bootjack fish had a significantly lower percentage of early maturing males. However, the Bootjack strain was eliminated as a production fish because there was no overall early growth advantage.

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REFERENCES

Ayles, G.B., and R.F. Baker. 1983. Genetic differences in growth and survival between strains and hybrids of rainbow trout (Salmo gairdneri) stocked in aquaculture lakes in the Canadian prairies. Aquaculture, 33: 269-280.

Babey, G.J., and Berry, Jr., C.R. 1989. Post-stocking performance of three strains of rainbow trout in a reservoir. North American Journal of Fisheries Management, 9: 309-315.

Behnke, R.J. 1992. Native trout of western North America. American Fisheries Society, Monograph 6. Bethesda, Maryland, 275 p.

Blann, V.E. and K. Tsumura. 1988. Rainbow trout broodstocks for coarse fish lakes. Habitat Conservation Fund Progress Report. Fisheries Project Report No. RD17, 11 p.

Blann, V.E. and K. Tsumura. 1989. Rainbow trout broodstocks for coarse fish lakes. Habitat Conservation Fund Progress Report. Fisheries Project Report No. RD22, 9 p.

Blann, V.E., T.I. Godin, and K. Tsumura. 1990. Rainbow trout broodstocks for coarse fish lakes. Habitat Conservation Fund Progress Report. Fisheries Project Report No. RD24, 30 p.

Brauhn, J.L. and H. Kincaid. 1982. Survival, growth, and catchability of rainbow trout of four strains. North American Journal of Fisheries Management, 2: 1-10.

Facchin, A., and G. King. 1980a. Lake survey and stocking records for the Williams Lake region of British Columbia. Volume 1-Management units 5-1 to 5-5. Ministry of Environment, Fish. Tech. Circ. No. 43.

Facchin, A., and G. King. 1980b. Lake survey and stocking records for the Williams Lake region of British Columbia. Volume 2-Management units 5-6 to 5-16. Ministry of Environment, Fish. Tech. Circ. No. 44.

Facchin, A., and G. King. 1980c. Lake survey and stocking records for the Thompson region of British Columbia. Management units 3-12 to 3-20 and 3-26 to 3-46. Ministry of Environment, Fish Tech Circ. No. 46.

Facchin, A., and G. King. 1983. Lake survey and stocking records for the Okanagan region of British Columbia. Ministry of Environment, Fish. Tech. Circ. No. 57.

Fay, C.W., and G.B. Pardue. 1986. Harvest, survival, growth, and movement of five strains of hatchery-reared rainbow trout in Virginia streams. North American Journal of Fisheries Management, 6: 569-579.

Hudy, M., and Berry, Jr., C.R. 1983. Performance of three strains of rainbow trout in a Utah reservoir. North American Journal of Fisheries Management, 3: 136-141.

Hume, J.M.B., and K. Tsumura. 1992. Field evaluation of two rainbow trout strains introduced to three British Columbia lakes. North American Journal of Fisheries Management, 12: 465-473.

Godin, T.I., and K. Tsumura. 1992. Rainbow trout broodstocks for coarsefish lakes. Habitat Conservation Fund Progress Report. Fisheries Project Report No. RD17, 11 p.

Godin, T.I., and K. Tsumura. 1993. Rainbow trout broodstocks for coarsefish lakes. Habitat Conservation Fund Final Report. Fisheries Project Report No. RD34, 20 p .

Northcote, T.G., and P.A. Larkin. 1956. Indices of productivity in British Columbia lakes. J. Fish. Res. Bd. Canada, 13(4), pp 515-540.

Sokal, R.R., and F.J. Rohlf. 1981. Biometry. 2nd ed. W.H. Freeman and Co. San Francisco.

Tsumura, K., and T.I. Godin. 1991. Evaluation of rainbow trout strains in small coarse fish lakes, three year summary: 1988 to 1990. Fisheries Project Report No. RD28, 40 p.

Wilkinson, L. 1988. SYSTAT: The system for statistics. Evanston, IL: SYSTAT, Inc.

Zar, J.H. 1984. Biostatistical Analysis. 2nd ed. Prentice-Hall Inc. Englewood Cliffs, N.J. Chapter 5.